An Activity Report on the Integration of Earth Observation Systems

Introduction

The terms of reference charged the IWGEO to "develop and begin implementation of the U.S. framework and ten-year plan for an *integrated*, comprehensive Earth observation system to answer environmental and societal needs …". The ten-year plan, if successfully implemented, will result in a national integrated Earth observation system . The integration of the planning, application, research, and data collection and management of Earth observing systems and derivative observations can yield enormous benefits. These benefits may be realized by cost savings through increased efficiency in system deployment, by more effective efforts in scientific research and in development of decision support tools, and by common practices in delivering results to the user community. In addition, an integrated national effort in Earth observing systems will make the national involvement with the broader international effort much more effective. Finally, many benefits of integration can be realized without large, new expenditures or long development lead times.

The Earth itself, in its natural state, acts as an integrated system. Thus, it should be observed and studied in an integrated approach. All the processes that influence conditions on the Earth, whether ecological, meteorological, or geological, are linked, and impact one another. A subtle change in one process can produce a dramatic effect in another. A full understanding of these processes and the linkages between them requires an integrated approach to the development Earth observation systems, and to scientific research using data from these systems.

Levels of integration.

Integration, like "good management" won't happen unless there is a clear understanding of what is meant by the term and what it involves. To help describe the concept of integration in the context of Earth observations, the discussion of the concept is cast or structured in four categories or levels. These are, in order or hierarchy of complexity and importance:

- Policy, planning, and management integration
- Functional and applications integration
- Scientific integration
- Technical systems integration.

Integration must take place at all of these levels to be effective at any level. It might be thought that integration should start at the bottom, with technical issues, and work up through the higher levels. Technical integration concerns observation platform specifications, data retrieval, archiving, and distribution, and other enormously complex issues. The integration of technical systems is a necessary condition for higher levels of integration to be effective. However, it is unlikely that technical integration, at the base of the hierarchy, will occur unless there is policy, planning, and management integration at the top.

- <u>Policy, planning, and management integration.</u>

The purpose of this ten-year plan is to provide an integrated strategy for management, planning, and resource allocation for Earth observations for the United States over the next decade. This strategy should be consistent with and supportive of the international effort of Global Earth Observation System of Systems (GEOSS). To be effective as an integration tool, this plan should be used by individual agencies, bureaus, and departments, and by oversight Offices in the executive branch, for the planning, approval, and implementation of Earth observing systems and their applications.

This plan has begun the policy integration process by identifying the seven societal benefits as its goals. This is an important first step. Based on this decision, the integration processes at other levels can proceed;

because now it is clear (or clearer) what needs to be integrated in terms functional applications, scientific research and modeling, and Earth observing systems. Policy and management integration will need to be continued throughout the ten-year cycle of this plan through implementation of a governance structure to be determined later. It is crucial that all agencies and oversight Offices involved in the implementation of this plan actively participate in this management structure.

In the past, we have seen Earth observing systems have been deployed for research or data collection purposes, and then used, or expected to be used, by others for applications or operational purposes. In many cases this approach has worked well. In other cases, there is a mismatch between the original system design and life cycle planning and its ultimate application, either in terms of technical specifications or availability of operational funding. The intent of this plan is to lay the foundation for an integrated approach to policy development and management of Earth observations systems that will avoid these difficulties.

- Topical integration for applications

In order to get from raw observations to societal applications, several links in a chain will need to be forged. These links include data analysis, research, process modeling, and finally development of decision support tools. The development of a decision support tool for application is likely to require the integration of several chains of investigation of various topics.

For example, forecasting long-term sea level rise is a formidable scientific problem requiring the use of data from many observational systems. But for societal application more is needed than the relative elevation of sea level to the land. There is a need to assess the potential impacts of sea level rise or fall. This requires the use of multiple models, such as ocean storm forecasting and tracking, models of storm surge and tsunami run-up, and models of coastal erosion and beach transport. All of these processes must be modeled in coordinated approaches that give comparable results. The forecasting of impacts of sea level change should be based on the same model. The results should be interpreted in a comprehensive manner to determine the societal impacts of sea level change and to plan effective responses.

In many cases, integration of process modeling across societal themes is necessary. The same model for long-term sea level change could be used in climate studies, ecological forecasting, ocean resources, and disaster reduction. It makes no sense to use identical data but develop multiple models of the same phenomenon, one for each societal application or function.

Finally, attention should be given to the integration of how the results of Earth observations and Earth process modeling are transmitted to society. Effective communication of results is the crucial link between science and society. The scientific community needs explain the results of Earth observation programs in common, consistent, and understandable terms that will lead to reasonable and effective action.

- Scientific integration

The modeling of Earth processes, in the ideal case, should be based on all relevant data. This is an important element of scientific integration. Technical systems integration, discussed below, should facilitate bringing together all relevant data to a particular problem.

All paradigms of an Earth process begin as research efforts and evolve, in some cases, to operational applications used in routine forecasting. It is important that research continue to refine existing models and develop new paradigms. Different models for the same process can help define the uncertainty in the results of each. However, multiple models of the same process that give widely divergent results may cast doubt on all models of the process. At some stage, integration of scientific thought and research into “community models” of Earth processes should be encouraged and adopted as an objective within the goals of this plan.

If integration efforts result in widely accepted community models of Earth processes, these models can play an important role in defining future observational needs and systems. Sensitivity studies using widely accepted models should show what new data are needed to improve the results of the model, to extend its application, or to reduce uncertainty in the results. These studies may point to those observations that are absolutely crucial to improving results, and may, in some cases, show that some proposed observational systems will provide data that have little or no impact on the results.

- Technical systems integration

The integration of Earth observation data can greatly enhance research and operational applications. Effective and efficient use of data and derivative information are directly related to the format and structure of the observations, associated meta-data, and data management and distribution systems. There is a need to integrate data management systems to the extent that all relevant data can be obtained with ease and used with confidence in any research study or application.

Integration considerations should also address observing system evolution. Observing system upgrades, new systems, system replacements, etc. all need to be considered in the context of a structured system integration approach. The significance and role assigned to models and other decision support tools in the integration process should also be considered. In some cases observing system experiments can be conducted to provide an objective, quantitative assessment of "how much something helps and contributes." However, objective analysis is not possible in every case and a well-disciplined subjective evaluation will be necessary.

It may be possible to achieve substantial efficiency through the physical integration on observing systems on the same platform or at the same ground site. Whenever possible, thorough consideration should be given to sharing space platforms and ground or ocean observation site and facilities.

Common Challenges and Earth Observation System Gaps

Some of the gaps (or needs) and challenges relevant to the societal focus areas are common between two or more focus areas. Were possible, these challenges and needs should be addressed in an integrated, coordinated manner.

- Common Challenges

Across many of the societal themes, there are common challenges that require attention and resolution. Salient among these are the following: Limits in access to data

  - Eroding infrastructure of underpinning technical observation systems.
  - Large spatial and temporal gaps in current systems.
  - Some areas of duplication in current systems.
  - Inadequate data integration and interoperability
  - Uncertainty over continuity of observations
  - Sub-optimal level of user involvement
  - Lack of relevant processing models and systems to transform data into useful information and decision support tools
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- Common gaps or needs.

Given these challenges, the following gaps and needs were found common to one or more societal focus area: (examples only for this draft)

  - High resolution land surface topography

- Remotely sensed land cover and land use data
- Direct measurements of ocean surface conditions
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Integration issues and opportunities across societal focus areas

Given the common challenges, gaps, and needs described above, the following are examples (not meant to be a comprehensive list) of integration actions that should be carried out under the aegis of the national ten-year plan:

Policy, planning, and management integration

- Complete ten-year plan for the national plan
- Implement a inter-agency coordination structure for implementation of the national plan
- Annually review and amend, if necessary, the national plan

<u>Topical and applications integration</u>

- Develop comprehensive decision support tools and systems that are based on all relevant topical studies and models.
- Develop and implement standards for forecasts, predictions, and, if required, warnings of Earth processes.
- Develop and implement common systems and practices for communication and "visualization" of results.

<u>Scientific integration in research and process modeling</u>

- Develop comprehensive, "community" models of Earth systems and processes – oceans, ice, land, atmosphere, solid Earth, and the biosphere.
- Drought
- Carbon cycle
- Sea level

<u>Technical integration of Earth observation systems.</u>

- Sustained maintenance and modernization of underpinning, or keystone, monitoring systems.
- Develop and enforce common data standards, including meta-data, and data management practices
- Where possible, develop and share multi-use data acquisition platforms and sites.
- Implement the deployment of specific observational systems that will have applications in multiple societal focus areas
    - XYZ - High resolution land surface topography
    - Landsat - Land cover and land use
    - ABC - Ocean surface state

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Integration issues relative to individual societal focus areas.

Realizing that progress cannot be made in some focus areas without systems and actions that are unique to that area, the following additional priorities should be recognized in each focus area.

- Disaster reduction
- Ocean resources
- Ecological forecasting
- Environment and human health
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International Integration

In due course this ten-year national plan will be defining actions that will complement and support the ten-year Implementation Plan being developed by the international *ad hoc* Group on Earth Observations. This international plan will be ' …based on user requirements and building on existing systems, for a comprehensive, coordinated, and sustained Earth observation system of systems." The integration of the national plan and the international plans, and subsequent implementation of the two plans, should be carried out to the mutual benefit of both. The details of integrated planning and implementation will be developed as the plans evolve and as the national management and international governance structures are specified.

(developing)

Assessment of future Earth observing systems

The assessment of future earth observing systems should hinge on the ultimate application of data from these systems in addressing one or more of the seven societal focus areas. The assessment should be based on a comprehensive plan that has been well vetted in the relevant scientific community. The plan should include system specifications, data management, costs, and deployment schedule. The plan should also include a justification that shows how the data from the system will be used in improving science-based models of an Earth process or phenomenon.

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